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SST

AN ECONOMIC ANALYSIS

Part I. Executive Summary

PRELIMINARY

SUPPLEMENT II

UNITED STATES DEPARTMENT OF COMMERCE

[redacted]

EXPLANATION OF RELEVANCY OF CONCLUSIONS AND DATA CONTAINED IN THE SST ECONOMIC ANALYSIS REPORTS PREPARED BY THE DEPARTMENT OF COMMERCE

In an effort to provide as complete a history as possible of the course of the SST program, materials consisting of Part I, Executive Summary and Supplements, and Part III, Contractor's Reports*, have been made publicly available. However, all persons using these materials should be advised that the data and conclusions pertaining to the SST designs contained therein are not current and have been superseded by the SST designs submitted to the FAA September 6, 1966, which were the basis for the Economic Feasibility Report prepared by the FAA in April 1967 and for the reports of the Economic Research Contractors submitted December 31, 1966. Using the superseded designs and the related economic data for comparisons with economic characteristics of other aircraft, both American and European, could be misleading and not representative of what was achieved with the more recent SST designs.

Because of the changes in development costs and total program costs and because of the provisions of the Phase III contracts with the airframe and engine manufacturers, the financial data and conclusions contained in the Executive Summary relating to the financial capability of the manufacturers do not reflect their financial capability in the context of the current program or their general financial position.

Accordingly, the materials attached hereto should be viewed as predominately historical in character.

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* Part II of the SST Economic Analysis was never issued.

[redacted]

THE SECRETARY OF COMMERCE
WASHINGTON, D.C. 20230

Honorable Robert S. McNamara
Chairman, SST Advisory Committee
Department of Defense
Washington, D. C.

Dear Bob:

In your letter of April 1, you requested that I provide the SST Advisory Committee with information dealing with the following questions:

a. the amount of capital at risk in the SST Program,

b. the profitability of SST airlines' operations as compared with those of current subsonic jet operations, and

c. the financing alternatives through development and production.

The first two of these questions have been treated in Supplement I (dated April 30, 1965) of the SST Economic Analysis report; the third is treated here.

I am concurrently forwarding copies of this report to Mr. Najeeb E. Halaby, Administrator, Federal Aviation Agency, and to Mr. Kermit Gordon, Director, Bureau of the Budget.

Sincerely yours,

Secretary of Commerce

Enclosure

[redacted]TIAL

CAPSULE SUMMARY

THE QUESTION OF PROGRAM FINANCING AND CONTROL

With the decision made to proceed with the SST Program, the central question becomes:

How shall the Program be financed and managed?

The SST Economic Analysis shows that the combined financial ability of the U.S. domestic trunklines and manufacturers is adequate for a substantial (and even preponderant) share in the SST Program financing. The fact that ability for private financing exists is of little consequence unless incentives can be created which will stimulate private investment. Willingness to invest is inseparable from the question of control of the SST Program. The choice here is bipolar: control must be vested either in the private sector or in the public sector. In either case, appropriate roles for the private and public sectors must be defined, risks shared, and responsibility for the controlling decisions assigned.

1. ALTERNATIVE APPROACHES

Table 1 presents in summary form a number of alternative approaches to the management and financing of the SST Program. The bipolar alternatives are as follows:

a. Government underwriting of risks

(1) FAA Plan A (or equivalent)

(2) Guaranteed loans

b. Private underwriting of risks

(1) Commerce approach

(2) "ComSat" approach

The FAA plan, guaranteed loans, and the "ComSat" approach have been elsewhere described; the Commerce approach is detailed in the attached supplement M1.

The higher risks and financial requirements of the SST Program necessarily require some modification of the historical relationships between Government, the manufacturers, and the airlines. The question is whether modifications as extreme in nature and extent as those suggested by the FAA or the proponents of guaranteed loans are necessary or desirable.

2. ANALYSIS OF PROGRAM RISKS

A set of subjective estimates of the time profiles of risks, safety and economic, have been secured from the manufacturers and principal airlines. These are presented in supplement M2, together with a number of letters from the corporate respondents.

The prospects for program success are seen to be sufficiently favorable to raise the question as to whether the SST Program cannot (and should not) proceed under private financing and control.

Table 1. Alternative Approaches to the Management and Financing of the SST Program

	Government Underwriting of Risks		Private Underwriting of Risks	
	FAA Plan A	Guaranteed Loans	Commerce Approach	"ComSat" Approach
1. Process for making product and market decisions	a. The Government will manage the SST development program up through aircraft certification for commercial service. The Government will finance 90 percent of prototype development (Phase III) and 90 percent of the production development and aircraft certification (Phase IV). Holding the power of the purse, the Government (through its explicit approval of designs) must inevitably specify the aircraft and determine its market timing, as proposed by FAA. b. Production of the SST (Phase V) will be supported by Government guaranteed loans. The airlines will be required by FAA to make down payments and progress payments which are greater than those for past aircraft. c. The Government will protect the manufacturers against catastrophic financial loss.	a. A number of variants have been proposed which seek to limit Government responsibility to the administration of provisions for guaranteed loans. Under FAA Plan B, the Government assumes the preponderant risk, guaranteeing loans for development in the same cost-sharing proportions as in Plan A. Under other variants (e.g., Ives-Whitehead, Arnold M. Grant), the Government assumes the entire risk. The limitation of Government responsibility to loan administration is clearly untenable as public policy. The Government would be writing a blank check if it were to guarantee loans without first approving the aircraft specifications, and, second, exercising sufficient oversight to assure efficient program implementation. Again as in FAA Plan A, by holding the power of the purse, the Government must specify the aircraft and determine its market timing. b. Production of the SST will be supported by Government guaranteed loans. c. The Government will protect the manufacturers against catastrophic financial loss.	a. Performance specifications and market timing will be hammered out between the manufacturers and the principal airlines. If the airlines desire, and are willing to pay for it, they may sponsor competition between manufacturers. Design and development will be financed principally out of the joint airlines-manufacturers resources, with sharing to be determined between them. Government contributions, while substantial, will deliberately be made indirect so as to permit private management of the SST Program. Subcontractors may participate in the program financing. b. In the production phase, fixed investment in facilities will be financed by the manufacturer by a combination of internally generated cash, debt, and sale of stock. c. The production pipeline will be treated as a working capital requirement financed by the manufacturer through a combination of its own resources, airline advance payments, the excess, if any, of accounts payable over receivables, and revolving bank credits. The primary incentives for such private risk-taking are: (1) The desire to secure private control of the program, the historically normal situation. (2) The tax credit approach permitting substantial, but indirect, Government participation--thereby lessening private risks.	a. Performance specifications, degree of competition, and market timing will be determined by the SST DevCorp, with advice from the manufacturers and principal airlines. Design and development will be financed through sale of securities to the public (and to the manufacturers and airlines, if parallelism with ComSat is maintained). Government contribution will be indirect (through sponsoring related technology, again as in ComSat). Upon completion of development and certification, the SST DevCorp would sell its rights to, or contract with, the manufacturers for production of the aircraft. b. In the production phase, fixed investment in facilities will be financed by the manufacturer by a combination of internally generated cash, debt, and sale of stock. c. The production pipeline will be treated as a working capital requirement financed by the manufacturer through a combination of its own resources, airline advance payments, the excess, if any, of accounts payable over receivables, and revolving bank credits. Several questions may be raised regarding the ComSat concept: (1) ComSat is an operating utility: SST DevCorp has no operating functions. (2) The division of functions, responsibilities, and rewards may not be acceptable to the manufacturers.
2. Responsibility for management financing, and risk-taking	During development, the Government will take the preponderant risks and responsibility for management. During production, the Government will take comparably great risks, and retains responsibility for oversight.	Throughout the program, the Government will take the entire (or, at least, preponderant) risks, and retain the responsibility for oversight.	The private sector will take the preponderant risks, and retain responsibility for management.	The private sector will take the preponderant risks, and retain responsibility for management.
3. Necessary governmental action	Congressional authority and appropriations are required.	Congressional authority is required.	Congressional authority is required.	No action is required.

[redacted]

3. DESIGN COMPETITION AND PRODUCT IMPROVEMENT

Looking beyond the phase of design competition provided under Option I, one must consider the nature and extent of competition needed to insure continuing improvement of the SST. In supplement M3, certain of the economic consequences are analyzed of continuing parallel competition through prototype flight test and also through certification. The results indicate that a major improvement in operating cost is required to justify this form of competition. An alternate form of competition, "leapfrog" in nature, is suggested between one manufacturer proceeding with the currently proposed SST engine concepts and a second manufacturer with an engine embodying advanced concepts and entering airline service in the 1978-80 time period. Such a leapfrog arrangement would preserve competition between manufacturers and, possibly, yield benefits greater than the parallel arrangement.

M1. A PLAN FOR PRIVATE FINANCING AND CONTROL

The plan suggested here recognize~~d~~s the basic preference of the manufacturers and airlines to implement the SST Program through private management, financing, and risk-taking, and provides the Government actions needed to make this feasible and attractive.

M1.1 THE HISTORICAL METHOD FOR PROGRAM FINANCING AND CONTROL

The basic product and market decisions for commercial aircraft have historically been made as follows:

a. The manufacturer usually has begun with a military prototype. Performance specifications and market timing for the commercial version have been hammered out between the manufacturer and the principal airlines, all under the prod of of competition. Design and development have been undertaken and financed entirely out of the manufacturer's internally generated cash resources.

b. In the production phase, fixed investment in facilities has been financed by the manufacturer by a combination of internally generated cash, debt, and sale of stock.

c. The production pipeline has been treated as a working capital requirement financed by the manufacturer through a combination of its own resources, airline advance payments, the excess, if any, of accounts payable over receivables, and revolving bank credits.

The manufacturers have taken the preponderant risks, managed the entire program, and reaped the associated rewards. No direct governmental action has been required.

M1.2 ELEMENTS OF THE PLAN

The Commerce approach preserves many of the desirable features involved in this historical relationship between airlines and manufacturers. With predominantly private risk-taking, the private sector naturally assumes control of the SST Program. The Government plays an active role by advising and by assisting indirectly but substantially in program financing. The elements of the suggested plan are as follows:

a. The airlines would be permitted to make advance payments toward development, and to take these payments before Federal income taxes. Legislation would be necessary, which would be a one-time affair limited to the first batch of orders--perhaps 200. The net effect is for the outlay of the airlines to be only half from their own resources, the other half coming indirectly from taxes that would otherwise be paid. Recapturing this indirect subvention at later successful stages is, of course, possible. Airlines initiative might alternatively be stimulated by permitting them to charge off advance payments to research and development as a current expense.

b. To increase airline incentives to participate, the CAB, by an advisory ruling, may confirm that

such advance payments toward development would become part of the rate base, as is the current practice for aircraft on order. The next 10 years are likely to see excess earnings and pressures on airlines to reduce mail pay rates and fares. The greater the advance payments, the less would be the nominal earnings for rate-making, and the less the pressure on the airlines.

c. Finally, airlines ordering the first planes, up to a limit of 200, would pay only one-half of the development cost, but receive the other half from, and contingent on, differential profits of manufacturers on sales above 200. The manufacturers would thus receive the full cost initially. As this would apply to foreign, as well as U.S. airlines, it would serve as an incentive for them to order in advance, and make contributions to development on a basis comparable to that of U.S. airlines.

d. Risk-taking at each stage would be equal to the respective financial inputs of the manufacturers and airlines. For example, if manufacturers invested $500 million, that would be their risk. If airlines made advance payments of $1 billion, that would represent primarily their risk, rather than a liability of the manufacturers. The organizational device by which this limitation is accomplished would be the creation by the manufacturer of a separate but wholly owned subsidiary exclusively for the SST operation (or by some equivalent device). As is usual in the cases where this device is used, only the subsidiary would be liable for its undertakings, and only its limited assets would be available, in case of failure, to satisfy creditors. Risks would similarly be limited in the production and operating stages of the SST. The exact division of financial inputs and risk-taking would be settled, as in the past, between airlines and manufacturers.

The heart of this plan is the deduction of advance payments before taxes. Under Section 607(h) of the Merchant Marine Act, subsidized ship lines may set aside earnings <u>before taxes</u> for construction of vessels in the future. This provides an important precedent for the Governmental action needed here to stimulate private initiative.

M1.3 APPLICABILITY OF PLAN

In section A5 of the Executive Summary of the SST Economic Analysis, the questions of requirements for program financing and of availability of private funds were treated in detail. The principal finding was that:

> The financial requirements for the SST Program appear to be approximately within the combined availability of funds from the manufacturers and airlines, without major direct Government subvention. Since the availability of funds is that which would exist after all non-SST requirements are met, corporate survival would, in no case, be threatened.

For convenience, the summary Table A5.16 and Figures A5.2 and A5.3 from the earlier report are reproduced here:

Table M1.1 - Financial Summary of SST Development Requirements (FAA and PRC) and Private Funds Availability, 1965-74, without SST

[redacted]

Table M1.1. Financial Summary of SST Development Requirements (FAA and PRC) and Private Funds Availability, 1965-74, without SST (million $)

Period and pattern	One producer							Two competing producers					
	Development requirements			Financial ability[1]				Additional requirements			Additional ability		
	Total	Boeing	GE	Total	Boeing	GE[3]	13 Trunks	Total	Lockheed	UAC	Total	Lockheed	UAC
1965-9, Prototype: FAA	746	490	256					1,027	715	312			
PRC	986	588	398					1,402	701	701			
1. Normal				650	60	0	590				0	0	0
2. Normal with 1965 cash dividends . . .				837	70	0	767				0	0	0
3. Upper limit, 1965 cash dividends . . .				2,106	235	45	1,826				270	160	110
4. Upper limit, no cash dividends.				2,516	315	75	2,126				460	275	185
1970-4[2], FAA.	446	252	194					306	168	138			
PRC.	604	302	302					473	164	309			
1. Normal				613	60	0	553				0	0	0
2. Normal with 1965 dividends.				1,116	70	0	1,046				0	0	0
3. Upper limit, 1965 dividends.				2,791	235	45	2,511				270	160	110
4. Upper limit, no dividends.				3,201	315	75	2,811				460	275	185

[1]Additional sources may, under possible plans, be foreign airlines which place orders for the U.S.-made SST; and permissible charge-offs to military contracts of Research and Development and transition to civilian business.

[2]In this phase, 1970-2 is certification. 1973-4 is purely production. The requirement shown is for certification only.

[3]In the absence of other data, GE projections were made from the ratio of its sales from the Propulsion Division to sales of United Aircraft, applied to UAC totals.

[redacted]

Figure M1. 1 - Projected SST requirements and financial ability (one producer)

Figure M1. 2 - Projected SST requirements and financial ability (two competing producers)

These indicate the time-phased cumulative requirements for, and availability of, cash for the SST Program.

For reference purposes, projections of earnings statements, balance sheets, and cash flows for the 13 U.S. trunklines are shown in Table M1. 2 for 1970, 1975 and 1980. Since, as explained in the Executive Summary, constant earnings and other financial factors were projected for the manufacturers, there was no need to project balance sheets as such for them.

Under the proposed plan, financial availability is taken as follows:

a. before taxes,

b. after all non-SST requirements for working capital and for plant, property, and equipment, and

c. after payment of cash dividends at 1965 rates.

This corresponds to pattern 3 as described on pp 134-5 of the Executive Summary.

For the manufacturers, the before-taxes basis is normal, since they may expense their development costs under current tax regulations. For the airlines, this would require some form of legislation. While the device for Government assistance is shown here in the form of a tax credit, the same purpose could be accomplished by other equivalent devices, such as direct Government appropriation, loan, loan guarantees, etc. The pre-tax capitalization is considered preferable because it minimizes the direct Government role, is consistent with regulatory practice, and permits the normal price structure.

Table M1. 2. Projected Earnings, Balance Sheets and Cash Flows, 13 Trunklines (Million $)

	Actual		Projected		
	1963	1964	1970	1975	1980
A. Profit and loss					
Rate of return, percent	6.6%	10.9%	10%	10%	10%
Average investment	$ 2538.1	2716.6	3413.0	5122.2	7676.9
Return on investment after federal tax, before interest	166.6	296.9	341.3	512.2	767.7
Operating revenues	3332.2	3775.2	5119.6	7683.4	11515.3
Operating expenses	3059.4	3312.6	4528.5	6804.4	10206.9
Depreciation	373.5	345.4	498.1	748.5	1122.8
Other	2685.9	2967.2	4030.4	6055.9	9084.1
Operating profit	272.8	462.6	591.1	879.0	1308.4
Interest on debt	91.3	75.3	70.6	114.9	181.9
Profit before federal taxes	181.5	387.3	520.5	764.1	1126.5
Federal income tax	106.3	165.7	249.8	366.7	540.7
Net profit	75.2	221.6	270.7	397.4	585.8
B. Balance sheets					
Assets					
Working capital	231.6	211.3	432.5	641.0	952.7
Fixed capital					
Tangibles, net	2539.8	2968.4	3305.2	4874.0	7220.1
Intangibles	37.8	39.2	0.8	0.8	0.8
Total	2809.2	3218.9	3738.5	5515.8	8173.6
Liabilities and net worth					
Deferred taxes	252.6	332.2	186.5	186.5	186.5
Long term debt	1573.1	1668.0	1484.3	2404.9	3801.6
Net worth	983.5	1218.7	2067.7	2924.4	4185.5
Total	2809.2	3218.9	3738.5	5515.8	8173.6
C. Fund flows					
Funds in					
Net profit after taxes and interest	75.2	221.6	270.7	397.4	585.8
Depreciation	373.5	345.4	498.1	748.5	1122.8
New debt		94.9	142.6	215.5	327.5
Other	126.4	233.8			
Total	575.1	895.7	911.4	1361.4	2036.1
Funds out					
Dividends	38.9	42.6	135.3	198.7	292.9
Working capital increase	- 26.3	- 20.3	33.6	48.6	72.8
Property expansion	353.4	873.4	490.7	731.3	1095.4
Property replacement			251.8	382.8	575.0
Debt retirement	209.1				
Total	575.1	895.7	911.4	1361.4	2036.1

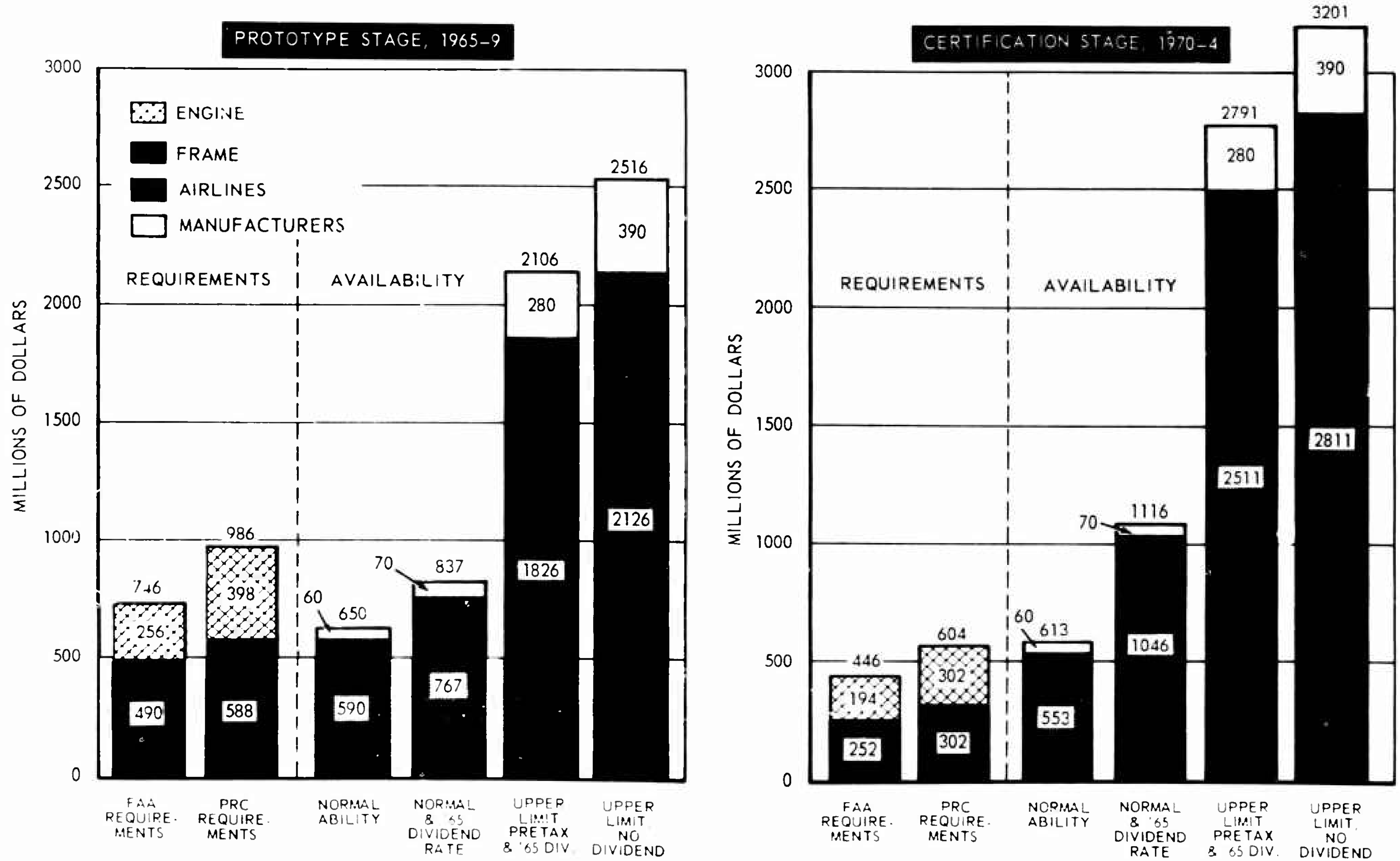

Figure M1.1. Projected SST requirements and financial ability (one producer).

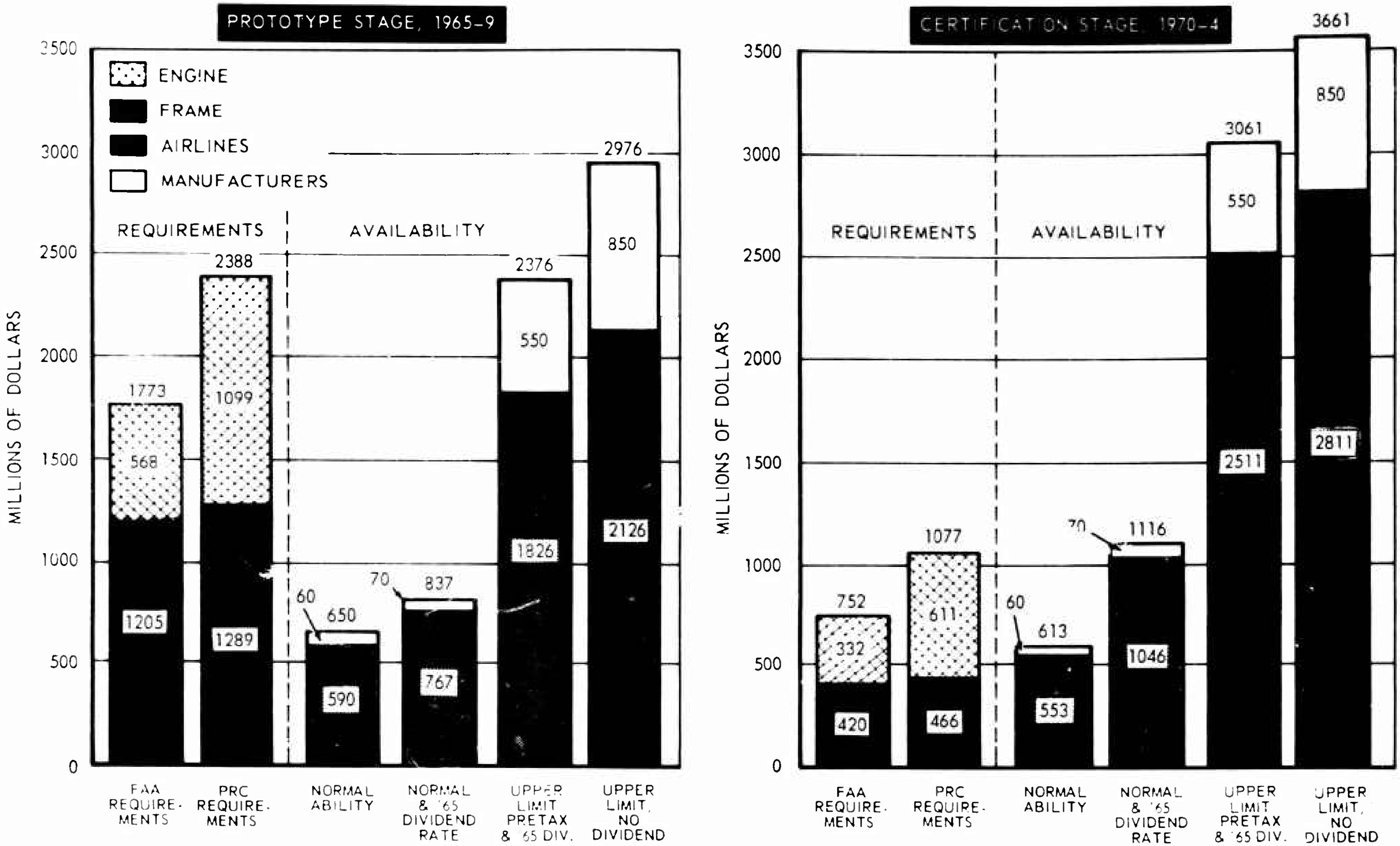

Figure M1.2. Projected SST requirements and financial ability (two competing producers).

Table M1.3 compares SST development requirements with company inputs under the Commerce plan for private financing and control for two illustrative cases:

1. The full requirement provided by manufacturers and U.S. airlines;
2. The effect of foreign airlines participating pro-rata through orders for 40 percent of the SST planes under the Commerce plan, and of the Government's underwriting 10 percent of the development costs as research.

Case 1 assumes that the foreign airlines have no interest in the SST. It therefore represents the extreme condition for commitment by the manufacturers and U.S. airlines to the SST Program. The Government contribution, later recoupable, would range from $380 to 510 million, or 32 percent.

Case 2 assumes that both U.S. and foreign airlines enter into the SST Program in approximate proportion to their expected share of aircraft requirements, and that the U.S. Government is further sufficiently interested (e.g., in advancing supersonic technology or in improving our balance of trade in aircraft) to invest 10 percent, or $120 to 160 million in the program. If SST cost and performance targets appear likely to be realized, Case 2 is then more likely to arise than Case 1. Whether from competitive necessity or advantageous economics, foreign airlines in the past have obtained the necessary resources to purchase planes from within their own operations or from their governments. It is reasonable to assume continued ability on this basis for SST purchases. The Government contribution through tax credit in this case, again recoupable, would range from $ 210 to 280 million. Total Government contribution would range from $ 330 to 440 million with the R&D investment, or 27 percent.

Incentives to the Government

The cost to the Government of the Commerce plan is initially in the corporate income tax that would otherwise be paid by U.S. airlines on earnings. If the SST Program fails and the airlines lose their investment in development, the loss would have been an equivalent charge against earnings. If the SST Program succeeds, the tax cost may be recaptured, partially or wholly, by a number of devices. For example, depreciation may be reduced by the amount of the tax saved; or the amount may be repaid out of airline earnings on the SST in excess of the regulatory allowance of 10 percent on investment, according to a determination to be signalled by the CAB.

The benefits to the Government are considerable in magnitude. It is relieved of the design and management burdens for a plane for which it is neither buyer nor seller. It is simultaneously cleared of the responsibilities and financial liabilities for the results in manufacture and operation. Instead of injecting directly or contingently 75 percent or more of the development costs (and, under various proposals, a substantial or preponderant part of the production costs with a contingent liability for operating results), the Government puts in approximately one-third in the form of tax benefits, which it may recapture if the SST succeeds. Finally, the Government takes an action consistent with a national policy of private enterprise and risk-taking.

Incentives to the Private Sector

The manufacturers thus far have been putting up one-fourth of development costs, the Government three-fourths. For a maximum increase to one-third under the Commerce plan, they would revert to their normal position of managing their own commercial plane program. The airlines, in return for their input, would retain their normal position of

Table M1.3 Examples Illustrating the Plan for Private Financing and Control of SST Development

		Prototype Phase (1965-9) (million $)			Certification Phase (1970-4) (million $)		
		Requirements		Availability	Requirements		Availability
		FAA	PRC		FAA	PRC	
Case 1	100%	$746	$986	$2,106	$446	$604	$2,775
Manufacturers:	33 1/3	249	329	280	149	201	280
U.S. Airlines:	66 2/3	497	657	1,826	297	403	2,495
Case 2	100%	$746	$986		$446	$604	
Manufacturers:	30	224	296	280	134	181	280
U.S. Airlines:	36	268	354	1,826	160	218	2,495
Foreign Airlines:	24	179	237	---	107	145	---
Government Research:	10	75	99	---	45	60	---

haggling with the manufacturers to achieve their best interests. Both airlines and manufacturers would be free of complex royalty repayment schemes, and would strike a blow for private enterprise and risk-taking.

M2. ANALYSIS OF PROGRAM RISKS

When viewed in the aggregate, the risks in the SST Program are difficult to assess and, hence, disquieting. However, when separately categorized and identified as to time of risk incidence, the problem of assessment becomes more manageable. Our approach to risk analysis is based on the fact that the probability of a favorable (or an unfavorable) outcome changes over time as the program passes through its various phases. For example, certain safety risks decrease significantly after successful prototype flight, and virtually disappear as the aircraft goes into commercial operation.

The task then is to develop time profiles for the various kinds of risks (safety and economic) at critical points in the SST Program. The method used involves the questioning of knowledgeable people in the aircraft and engine manufacturing industry and in the air transport industry as to their estimates of these risk profiles. To encourage candor, the anonymity of the responding individuals and their firms has been preserved. These subjective estimates are here presented to assist the SST Advisory Committee in calibrating its own assessment of program risks.

M2.1 THE QUESTIONNAIRE

Table M2.1, the questionnaire used, defines the various classes of risks and the points during the program to be considered. Seven possible program outcomes, three safety risks and four economic risks, are to be assessed in testing the hypothesis with which the Committee is now wrestling:

> That, as of today, an SST can be built that will have a cost per seat mile as low or lower than present subsonic planes at distances above 900 miles.

SST Safety Risks

The first of these cases involves the extreme risk that the aircraft design would be discarded for technical reasons, and the program abandoned. The salvage value would be chiefly advancement of technology. Although there have been virtually no such cases in commercial aviation, it does serve to define the outer limit of risk.

The second involves a serious technical flaw that is repaired, and the program goes on normally thereafter. This is illustrated by the voluntary temporary groundings of the DC-6, or the temporary reduction of cruising speed of the Electra while modifications were made serially for wing flutter. This risk does not force abandonment of a program. It may impair the market timing of a particular commercial plane as against competitors, as in the case of Comet IV and the Electra. But even here, later versions have gone on to successful marketing, commercially in the Comet case, and to the military in the case of the Electra.

The third case is "Safety success, no major problems," and requires no additional comment.

QUESTIONNAIRE FURNISHED

Table M2.1. PROBABILITY THAT CERTAIN EVENTS WILL OCCUR AS OF THE YEAR AND STAGE SHOWN, GIVEN THE FOLLOWING ASSUMPTION:

That, as of today, an SST can be built that will have a cost per seat mile as low or lower than present subsonic planes at distances above 900 miles.

Stage and Year	Safety Risk 1	2	3	Economic Risk 4	5	6	7
As of today, 1965							
At end of 100-hours prototype testing, 1969							
At end of certification, 1972							
Airline operations:							
1973							
1974							
1975							
1976							
1977							

At each year, it is assumed that the original expectation is still unchanged, having neither bettered nor worsened, and the question is, what is the chance at that point that the risk event will occur in the future? For example, in 1972, with successful certification, the expectation is assumed still to be what it was in 1965: what is the probability that the plane will have to be junked in the next 5 years of airline operations because of unforeseen safety defects?

The risk cases are as follows:

1. Safety catastrophe: must be junked.
2. Safety catastrophe: fix and ok (like DC-6, Electra).
3. Safety success: no major problems.
4. Economic flop: DOC exceeds revenues (i.e., out-of-pocket loss).
5. Economic flop: revenues exceed DOC, but less than TOC (i.e., out-of-pocket profit).
6. Economic success: revenues exceed TOC.
7. Economic success: profits with SSTs greater than without SSTs.

SST Economic Risks

The extreme case (4) is an aircraft design which is so poor that its operation leads to an out-of-pocket loss. It does not pay to operate the planes already bought and like the extreme safety risk, this would result in program abandonment.

Case 5 is also an economic failure, but there is an out-of-pocket profit. Therefore, it might pay to continue to operate planes already bought (if the program had proceeded that far) but it would not pay to buy additional planes.

Case 6 is an economic success, defined as yielding a profit on an overall basis, i.e., revenues exceed total operating cost (TOC). This must be the minimum risk expectation underlying a decision to go forward with the SST.

Case 7 defines the upper limit of economic success, where profits with SSTs are greater than without SSTs.

Time Profiles of Risk

Given the definition of risk for each of the above seven cases, the questionnaire asks what the probability is (as of today) that the basic assumption will be realized. Then, assuming that the expectation remains the same, neither bettering nor worsening, it asks how this probability may be expected to change at certain future critical dates. These dates are:

a. 1969, at the end of 100 hours of successful prototype flight testing,

b. at certification in 1972, and

c. at each of the first five years of airline operation.

M2.2 THE ESTIMATION OF PROGRAM RISKS

After exploratory discussions to define terms, the following manufacturers and airlines have undertaken to provide subjective estimates of SST Program risks:

a. Boeing

b. Lockheed

c. General Electric

d. Pratt and Whitney

e. American Airlines

f. Northwest Airlines

g. Pan American

h. TWA

i. United Airlines

For the airframe manufacturers and the airlines, the risk probabilities apply to the entire SST airplane; for the engine manufacturers, they apply only to the engine.

With regard to the relative weight which should be attached to the various estimates, one engine manufacturer made the following comment:

> "To reiterate, we do feel that the chances of the powerplant's being an economic flop are practically zero. The airframe people may well feel the same way about their product. However, caution should be exercised before combining these probabilities. The maximum weight should be given to the airlines' assessment since they have the best appreciation of the overall system and how it affects their operating economics."

Typically, the manufacturers and airlines would form small teams of people (ranging from 4 to 12) who were highly knowledgeable in the business. Each individual would first prepare his own estimates, and then these would be combined after discussion into a single corporate estimate. In some cases, the company submitted the range of the estimates, as well as the consensus. A necessary subjective element characterizes the various estimates. This element reflects the past history of the particular company, the experience and personalities of the indivudal estimators, and the differences in interpretation of the problem intended to be defined and quantified by the risk table. On the whole, it would be expected that the manufacturers would be more optimistic of program outcome than the airlines, because of more intimate knowledge of their designs, and the fact that they are in the seller's position.

M2.3 THE SUBJECTIVE ESTIMATES OF RISK

Table M2.2 presents the estimates of the risk profiles relating to safety; Table M2.3 presents those relating to the economics of operations.

The action to be taken with respect to the SST Program depends strongly on the assessment of risks:

a. If the program outcomes involving the extreme safety or economic loss conditions (cases 1,4, or 5) appeared quite probable, one would terminate the program. The risk tables indicate that these are not the expected outcomes.

b. The favorable economic extreme (Case 7) likewise presents no problem. The SST Program would then be vigorously implemented. The tables show a split of opinion as to the likelihood of this outcome.

c. If the intermediate safety risk (Case 2) appears probable, one would concern himself with impact on market timing. Unless the probability were high, one would not terminate the program.

d. The intermediate economic risk (Case 6) can only be judged with respect to one's own threshold level for risk tolerance. The risk tables indicate a strong consensus that the SST will at least return a profit on revenues, with a reasonable expectation that this profit percentage will be greater than without the SST.

The prospects for success are seen to be sufficiently favorable to raise the question as to whether the SST Program could not (and should not) proceed under private financing and control.

Because of their possible interest to the SST Advisory Committee, a number of letters from various corporate respondents have also been appended.

Table M2.2. Safety Risk Probabilities (%), as Estimated by Nine Companies[1]

Risk Case-1: Safety Catastrophe: must be junked

Stage and year	MANUFACTURERS A	MANUFACTURERS B	MANUFACTURERS C	MANUFACTURERS D	AIRLINES E	AIRLINES F	AIRLINES G	AIRLINES H
As of today, 1965	0	1	1	1	1	1	14	1-
At end of 100-hours prototype testing, 1969	0	0.1	0.5	0.1	0.5	0.1	10	1-
At end of certification, 1972	0	0	0	0	0.1	0.5	8	0
Airline operations								
1973	0	0	0	0	0	0	4	0
1974	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0

Risk Case-3: Safety Success: no major problem.[2]

Stage and year	I[3] CASE-1	I[3] CASE-2	I[3] CASE-3
As of today, 1965		X	
At end of 100-hours prototype testing, 1969		X	
At end of certification, 1972		X	
1973		X	
1974			X
1975			X
1976			X
1977			X

Risk Case-2: Safety Catastrophe: fix and OK (like DC-6 or Electra)

Stage and year	MANUFACTURERS A	MANUFACTURERS B	MANUFACTURERS C	MANUFACTURERS D	AIRLINES E	AIRLINES F	AIRLINES G	AIRLINES H
As of today, 1965	2.5	70	2	10	33	6	45	5
At end of 100-hours prototype testing, 1969	2.5	40	1	2	32	3	30	2.5
At end of certification, 1972	0.5	20	0.5	1	30	1	24	1-
Airline operations								
1973	0	10	0.4	0.1	20	0.1	10	.01[4]
1974	0	3	0.3	0.1	10	5		0
1975	0	0.5	0.2	0.1	0	0	5	0
1976	0	0.05	0.1	0.1	0	0		0
1977	0	0	0	0.1	0	0		0

[1]The report of a tenth company was not received in time for inclusion here.
[2]Case 3 was usually taken as 100 minus the probability percentage for Case 2, and is therefore omitted, except for company I.
[3]Company I replied only as shown. The interpretation is that the most likely situation was considered to be Case 2 through the first year of operation, and thereafter Case 3.
[4]At the end of certification risk is negligible, but if any problem occurs, the probability is that it will occur after certification, and the industry must remain alert to this possibility.

[redacted]

[redacted]

Table M2.3. Economic Risk Probabilities (T), as Estimated by Nine Companies

Risk Case-4: Economic flop: DOC exceeds revenues

	MANUFACTURERS				AIRLINES			
Stage and year	A	B	C	D	E[3]	F	G[3]	H
As of today, 1965	2.5	1	2.5	0	0	20	15	neg.
At end of 100 hours prototype testing, 1969	2.5	0.1	2	0	0	5	10	0
At end of certification, 1972	2.5	0	1	0	0	0	5	0
Airline operations								
1973	0	0	0	0	0	0	5	0
1974	0	0	0	0	0	0	5	0
1975	0	0	0	0	0	0	5	0
1976	0	0	0	0	0	0	5	0
1977	0	0	0	0	0	0	5	0

Risk Case-6: Economic success: revenues exceed DOC

	MANUFACTURERS				AIRLINES			
Stage and year	A	B	C	D	E[3]	F	G[3]	H
As of today, 1965	92.5	90	95	99	90	40	50	99.5
At end of 100 hours prototype testing, 1969	92.5	95	97	99	90	65	60	99.5
At end of certification, 1972	92.5	99	98	99	94	40	60	100-
Airline operations								
1973		[illegible]	99	99	[illegible]	100	65	100-
1974	100	100	100	99	100	100	55	100
1975	100	100	100	99	100	100	45	100
1976	100	100	100	99	100	100	35	100
1977	100	100	100	100	100	100	25	100

	T[1]			
Stage and year	CASE-4	CASE-5	CASE-6	CASE-7
As of today, 1965		X		
At end of 100 hours prototype testing, 1969		X		
At end of certification, 1972		X		
Airline operations				
1973			X	
1974			X	
1975			X	
1976			X	
1977			X	

Risk Case-5: Economic Flop: revenues exceed DOC, but less than TOC.

	MANUFACTURERS				AIRLINES			
Stage and year	A	B	C	D	E[3]	F	G[3]	H
As of today, 1965	5	10	5	0	5	30	25	2-4
At end of 100 hours prototype testing, 1969	5	5	3	0	5	20	20	neg
At end of certification, 1972	5	1	2	0	3	10	15	0
Airline operations								
1973	0	0.5	1	0	1	0	5	0
1974	0	0	0	0	0	0	5	0
1975	0	0	0	0	0	0	5	0
1976	0	0	0	0	0	0	5	0
1977	0	0	0	0	0	0	5	0

Risk Case-7: Economic success: profits with SST greater than w/o SST.

	MANUFACTURERS				AIRLINES			
Stage and year	A[2]	B	C[2]	D	E[3]	F	G[2]	H[4]
As of today, 1965		70		99	5	15	10	75-90
At end of 100 hours prototype testing, 1969		90		99	5	20	15	95
At end of certification, 1972		95		99	3	35	20	99
Airline operations								
1973		98		99	1	60	25	99
1974		99		99	0	90	35	99
1975		100		99	0	100	45	100
1976		100		99	0	100	55	100
1977		100		100	0	100	65	100

[1]This reply is interpreted to mean that Case 5 was considered to be most likely through certification, and thereafter Case 6.

[2]Risk 7 was not estimated by this company.

[3]This company made the probabilities for the four economic risks sum to 100. This explains why the probabilities in Risk 6 declined with time, since they were reciprocal with the concurrent increases in Risk 7.

[4]To assure profits in excess of present jets, some of the ground rules will require modification of final design configuration, e.g., fuselage width appropriate to comfort. Also, there is substantially greater risk if the program management is only controlled by government, and not fully controlled by manufacturers and operators of the SST.

[redacted]

COMPANY-1
(Partial response)

The types of troubles of most concern from a safety aspect in the early part of an experimental program are in decreasing importance.

1. Powerplant failure
2. Stalled Flight Characteristics
3. Flutter
4. Mechanical Control Failures
5. Fuel System
6. Brakes
7. Fire
8. Structure

There have been several broad factors that have decreased the liklehood of catastrophe in the early flight testing. These are listed below in the same order as the risks listed above.

1. Jet engines, without propellers and their problems of control and structure, and with much greater integrity and life than piston engines. Large excess of power with jet engines during takeoff and climb.

2. Spoilers to give positive lateral control in stalled flight.

3. Greatly improved flutter theory and improved wind tunnel experimental techniques, plus flight test instrumentation with telemetering to ground observers.

4. Dual independent hydraulic controls with manual or other backup.

5. High flow and multiple feed path fuel systems.

6. Anti-skid brakes with improved hydraulic systems, plus thrust reversing.

7. Podded engines and simple powerplant installation to separate ignition source from fuel tanks.

8. Electrical strain gages, plus fail-safe design, and materials with higher fracture toughness.

The benefit of these improvements are that the limits of the flight envelope can be explored gradually, and corrections made before hazards become large. This means that the thoroughness of the flight test program are the greatest protection against loss during the early experimental period, but just as important, ensure that the airline operator will suffer no catastrophe.

There have been no recent transport airplane programs junked due to safety once they were put into service. There have been long term groundings to fix major troubles as follows:

Airplane	Trouble	Fix
DC-6	Fire due to fuel vent flow into cabin heater	Redesign of systems
M202	Wing spar fatigue	Improved design Failsafe structure on future designs
Electra	Propeller whirl due to engine mount failure	Multiple path engine mount
Comet	Pressurization burst due to fatigue	Tear stopper body design
Britania	Ice choking engine inlet	Duct heating
Not grounded		
377 DC-7	Propeller fatigue and control failures	Get rid of propeller

[redacted]

The last two airplanes were largely abandoned early by the major airlines because of persistent recurrent troubles associated with piston engines and large propellers.

The general factors learned above are all equally applicable to the SST. In addition, the SST may have problems due to heating. However, these are expected to show up more in maintenance rather than safety insofar as catastropic program failure or grounding for major redesign are concerned.

COMPANY 2

May 4, 1965

SST Study Group
Office of the Secretary
Department of Commerce
Washington 25, D. C.

Dear :

This letter will confirm and amplify the material we discussed during our telephone conversations on April 26 and 27th.

It might first of all be desirable to review our understanding at of the bases for estimating the probabilities of occurrence of certain events by various stages of the supersonic transport program.

We paraphrased the original problem statement in the following manner:

(a) Engineering and economic analyses indicate that it is now possible to undertake the design of a supersonic transport which can be expected to have safety and economic characteristics comparable with those of current subsonic airplanes.

(b) There is considerable uncertainty associated with an airplane design and the realized safety and economic characteristics may be better or worse than the design objectives. What is a measure of the dispersion of real characteristics relative to design objectives?

(c) As the program continues through various stages the achieved characteristics become evident and there is less and less uncertainty associated with whether or not the design objectives have been realized. What is a measure of the probability of having discovered the real characteristics of the airplane at various stages of the program?

Our estimate in 1965 of the probability of the airplane demonstrating the safety and economic risks of the problem statement is:

Safety Risk			Economic Risk			
1	2	* 3	4	5	* 6	7
.010	.333	.657	--	.050	.900	.050

* These risks are the design objectives.

Our estimate of the probabilities of discovering by certain stages of the program that the airplane actually has the characteristics defined by the risk classifications and different from the design risk classification is:

Probability of discovering that airplane has characteristics defined by risk classification

	Safety Risk			Economic Risk			
Program Stage	1	2	3	4	5	6	7
1965	.000	.000	---	---	.000	---	.000
End of 100 hrs. testing	.500	.050	---	1.000	.000	---	.000
End of certification-1972	.900	.100	---	1.000	.400	---	.400
End of operation-1973	.950	.400	---	1.000	.800	---	.800
End of operation-1974	1.000	.700	---	1.000	1.000	---	1.000
End of operation-1975	1.000	1.000	---	1.000	1.000	---	1.000

The probability of the airplane having certain off-design characteristics can be combined with the probability of discovering these deviations by various program stages to evaluate the future probability of the airplane being discovered to be in any one of the seven risk categories.

Probability of future (beyond program stage) risk categorization of airplane

	Safety Risk			Economic Risk			
Program Stage	1	2	3	4	5	6	7
1965	.010	.333	.657	--	.050	.900	.050
End of 100 hr. testing	.005	.316	.679	--	.050	.900	.050
End of certification-1972	.001	.300	.699	--	.030	.940	.030
End of operation-1973	--	.200	.800	--	.010	.980	.010
End of operation-1974	--	.100	.900	--	--	1.000	--
End of operation-1975	--	--	1.000	--	--	1.000	--

In the case of the safety risks we assigned a very low probability of .01 to the airplane being so unsafe that the project would have to be cancelled. We can think of no case where this has happened for a design with a reasonable mission. The Comet had a very unfortunate history and did not have a very bright economic potential nevertheless development continued until the airplane was safe. In the event the airplane had such dangerous characteristics that it was necessary to cancel the project this would probably be discovered early in the program - in our opinion there is a probability of 0.50 that this would be discovered by the end of 100 hours testing and a probability of 0.9 that it would be discovered prior to certification.

History shows that the probability of discovering safety characteristics that require major modification (Electra, DC-6, Comet, etc.) is quite low prior to the end of certification and a probability of 0.10 was assigned to this case. It was assumed that such characteristics if present would be discovered by the end of 1975.

As time goes by safety risks 1 and 2, if present, are more and more apt to have been discovered. At each successive stage of the program it becomes increasingly probable that the airplane has indeed met the design safety objectives.

In a similar manner it becomes increasingly probable that the airplane has the estimated economic characteristics as various stages of the program are passed without the discovery of economic characteristics which are either markedly less favorable or markedly more favorable than the estimated characteristics.

In our opinion delay of certification from 1972 to 1974 would not change these probabilities. It is believed that the airplane manufacturer would change any production tooling as necessary to cater to any probable safety hazards or economic deficiencies which might be discovered during the certification program directed towards a 1972 date. Philosophically, however, we would prefer that the manufacturer did not have to commit to hard tooling until after a considerable amount of flight test experience.

Yours truly,

[redacted]

COMPANY 3

April 21, 1965

U. S. Department of Commerce
Washington, D. C.

Subject: SST Program Probability

Dear

During our meeting with you on April 12 we agreed to make an attempt to fill out your chart listing risks inherent in various stages of the development program of a U. S. SST. We are submitting a chart in which we have filled in the percentages and wish to indicate to you that these must be considered of a preliminary nature because has not had the opportunity to review this.

As we indicated to you, we thought that an additional column should be added which was identified at the time of our meeting as Column 2A. In reviewing this we feel that this new column is in effect the difference between Column 2 and 100% and should be so regarded in all cases.

In addition, we felt that there would be some material difference in the probabilities if a prototype program were followed rather than a production program with the first prototypes being in reality early production airplanes. Where two figures are shown on the chart the one in parentheses indicates a prototype program with production two years later than shown.

The numbers as filled in are the results of the individual analysis by four people, each working separately and basing his numbers on experience to date with the SST program and applying his best judgment. The attached sheets list the consensus of this group as well as the percentage spreads.

Needless to say, we have had some problems with the semantics. For instance, where you have used the word "assumption" in the beginning we have taken this to mean "objective." If we were to make the assumption as stated, then there would be no risk. The Column 1, Safety Risk, is considered to be low because in our opinion the state of the art with respect to fail-safe and safe-life techniques is considerably advanced. In addition and in support of safety, are much improved wind tunnel and other testing techniques

which tend to assure elimination of catastrophic/junk types of failures. The number 6 column, Economic Success, was the most difficult one to assess. Our studies to date show that an American SST could have as high a rate of return as existing subsonic jets. However, subsonic jets are being developed which are superior and the supersonic aircraft must be further improved to keep pace.

As soon as returns, we will review the foregoing with him and will be in touch with you with respect to any changes that may come from such a review.

Very truly yours,

Attachment

PROBABILITY THAT CERTAIN EVENTS WILL OCCUR AS OF THE YEAR AND STAGE SHOWN, GIVEN THE FOLLOWING OBJECTIVE:

THAT AS OF TODAY AN SST CAN BE BUILT WHICH WILL HAVE A COST PER SEAT MILE AS LOW OR LOWER THAN PRESENT SUBSONIC PLANES AT DISTANCES ABOVE 900 MILES.

	Percentage of					
	Safety Risk (See Notes)		Economic Risk			
Stage and Year	1	2	3	4	5	6
As of today, 1965	1	6(3)	20(10)	30(20)	40(50)	15
At end of 100-hours prototype testing, 1969	.1	3(1)	5(3)	20(15)	65(75)	20(25)
At end of certification, 1972	.05	1	0	10(0)	80(100)	35(40)
Airline operations: 1973	Negligible	.1	0	0	100	60(70)
1974	Negligible	Negligible	0	0	100	90(100)
1975	Negligible	Negligible	0	0	100	100
1976	Negligible	Negligible	0	0	100	100
1977	Negligible	Negligible	0	0	100	100

NOTES: 1. Figures in parentheses are probabilities if prototype program is followed. If parentheses are not shown, probabilities are considered same for production or prototype program.

2. See Page 2 for spread of assessments from four persons.

The risk cases are as follows:

1. Safety Catastrophe: Must be junked.
2. Safety Catastrophe: Fix and okay (like DC-6, Electra).
3. Economic Flop: DOC exceeds revenues (i.e., out-of-pocket loss).
4. Economic Flop: Revenues exceed DOC but less than TOC (i.e., out-of-pocket profit).
5. Economic Success: Revenues exceed TOC.
6. Economic Success: Profits with SST's greater than without SST's.

(SPREAD OF ASSESSMENTS FROM FOUR PERSONS)

PROBABILITY THAT CERTAIN EVENTS WILL OCCUR AS OF THE YEAR AND STAGE SHOWN, GIVEN THE FOLLOWING OBJECTIVE:

THAT AS OF TODAY AN SST CAN BE BUILT WHICH WILL HAVE A COST PER SEAT MILE AS LOW OR LOWER THAN PRESENT SUBSONIC PLANES AT DISTANCES ABOVE 900 MILES.

	Percentage of					
	Safety Risk		Economic Risk			
Stage and Year	1	2	3	4	5	6
As of today, 1965	.1-5	1-80	10-20	25-40	40-55	5-40
At end of 100-hours prototype testing, 1969	0-1	.1-60	1-10	15-33	50-75	10-45
At end of certification, 1972	0-.2	.05-10	0-1	0-20	80-100	20-50
Airline operations: 1973	Negl.-.1	Negl.-.5	0	0-5	95-100	55-70
1974	Negligible	Negligible	0	0	100	75-100
1975	Negligible	Negligible	0	0	100	100
1976	Negligible	Negligible	0	0	100	100
1977	Negligible	Negligible	0	0	100	100

NOTE: See Page 1 for risk case definition.

[redacted]

COMPANY 4

May 4, 1965

SST Study Group
Office of the Secretary
Department of Commerce
Washington 25, D.C.

Dear Mr.

Replying to your questionnaire, attached are some personal opinions of the Safety Risks and Economic Risks of different SST programs.

Our Development Engineering people first assumed that there would be a choice of 3 programs - A, B and C. Program A is similar to the "tightest" schedule with perhaps a 1972 certification date, which you mentioned. B is with a single prototype, and C with two prototypes. (Attachment I)

They then made the premise (Attachment II) that all milestones were satisfactory under each program.

With each program, Safety Risks for 1, 2 and 3, were estimated, and these are shown on Attachment III, in both numerical and graph form.

Before going into the Economic Risks, I wrote down what I thought were the further assumptions which had to be stated. (Attachment IV)

Finally, we all sat down and each of us gave our personal opinions of the chances of the SST covering directs, covering TOC's, covering TOC's but being less profitable than sub-sonic jets, or covering TOC's and being more profitable under each of the 3 programs - A, B or C.

You will notice that we thought only 2 years of operation were significant -- the 1st and 3rd year. Depending upon the program followed, these might be 1975 and 1977, or 1978 and 1980, or possibly even some other dates in the future. (Attachment V)

All of these estimates are long ways from being position on the SST, but are merely personal attempts to weigh the risks of one development program vs. another, for the purposes you told me about over the telephone.

If you have any questions, please let me know.

Very truly yours,

Attachments (5)

[redacted]

Attachment I

Program A - Assumes R.F.P. type program with tight adherence to initial schedule, minimal direction by ultimate purchasers, single model prototypes, and early production commitment.

Program B - Assumes Program having strong direction from purchasers, flexibility to pace program by achievements, production commitment after 100 Hr. test, and single model prototypes.

Program C - Same as "B" except two models of engine and airframe are prototyped.

Attachment II

PREMISE:

All probabilities are based on the assumption that each milestone is satisfactorily passed and that each such achievement improves the subsequent probabilities of ultimate success.

4/29/65

[redacted]

Attachment III
Page 1

SAFETY PROBABILITIES - SST

	PROG.	Hazard Level 1	2	3
	A	14	45	41
1965	B	9	35	56
2.5	C	5	25	70
	A	10	30	60
100 Hr.	B	6	20	74
0.5	C	3	15	82
	A	8	24	68
CERT.	B	5	16	79
2	C	2	10	88
After	A	4	10	86
1st. Yr.	B	3	8	89
3	C	1	5	94
After	A	0	5	95
3rd. Yr.	B	0	4	96
	C	0	3	97

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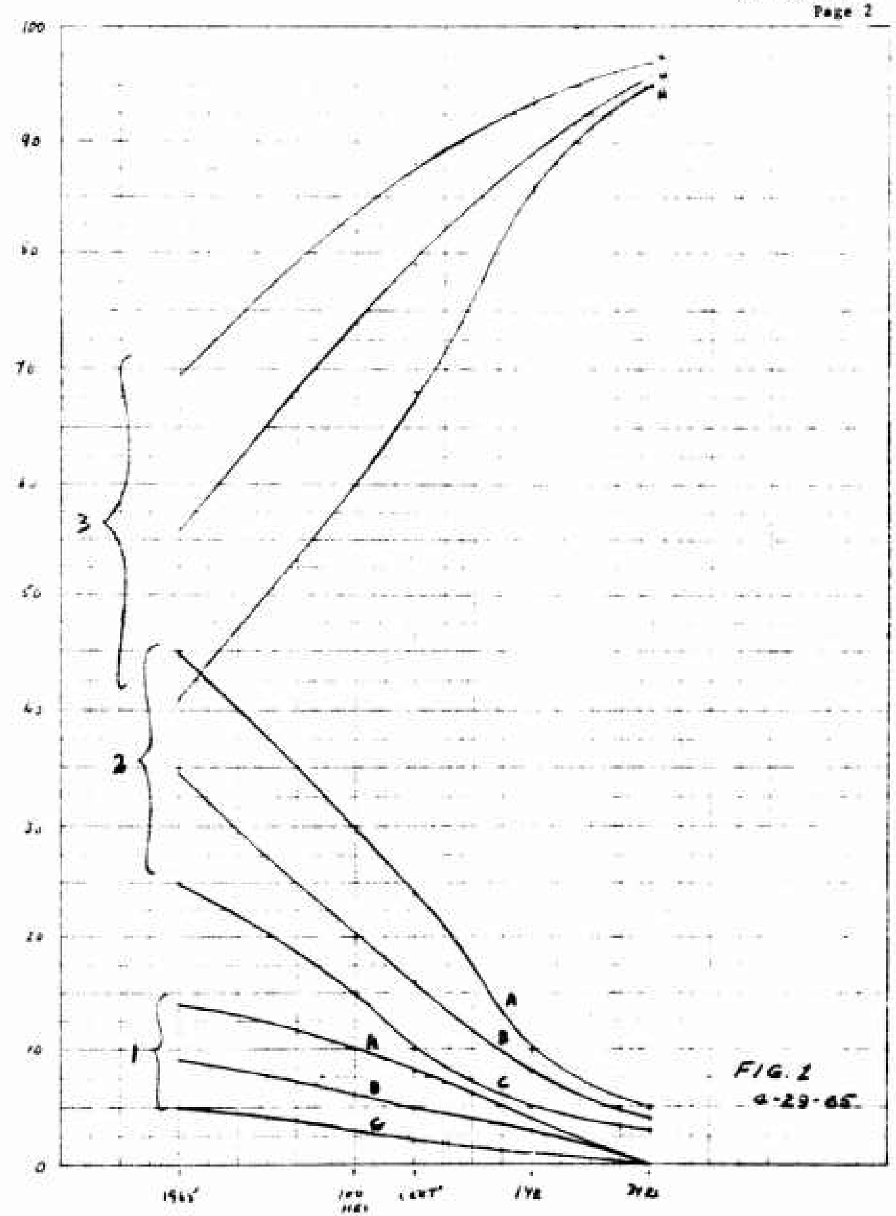
Attachment III
Page 2



[redacted]

Attachment IV

ECONOMIC COMMENTS: The economic risk evaluation involves several more assumptions which are not stated. The most important of these are that:

1) The introductory expenses and problems relative to SST investment are of the same relative magnitude as were those with the sub-sonic jets.

2) The government policies which could drastically change the SST's economies, such as paying for development expense through royalties versus through original sales price, or the effect of kerosene taxes upon SST operating costs, are not adverse to the SST.

3) The rate of inflation of sub-sonic operating costs doesn't halt at 1965 level.

4) The fare structure for the years 1965 through 1977 is similar to 1965's.

5) The production rate of the SST's insofar as it affects the load factors, not only of the SST's, but of all sub-sonic equipment is not more than 50 per year.

6) The overall growth rate of the economy and of airline revenues is about as forecast. If all of these developments were adverse, the SST may not recover DOC's. If all are reasonably favorable or stable, the SST operation of the mid-1970's should be more profitable than an all sub-sonic jet operation.

Attachment V

RISK

		4				5				6				7			
	PROG.	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
	A	25	10	12	30	25	20	30	50	50	35	58	15	0	35	0	5
1965	B	15	7	7	22	15	16	10	37	60	39	81	34	10	40	2	7
2.5	C	10	4	5	15	10	8	7	25	60	43	84	50	20	45	4	10
	A	20	7	8	20	20	16	20	40	60	35	71	35	0	42	1	5
100 Hr.	B	10	5	6	17	15	10	12	30	55	37	79	46	20	48	3	7
0.5	C	5	3	4	10	10	6	5	20	55	39	85	60	30	52	6	10
	A	10	4	8	20	20	12	13	30	60	39	78	40	10	49	1	10
CERT.	B	5	2	5	10	10	6	10	22	65	35	81	53	20	57	4	15
2	C	1	1	3	5	5	3	4	15	54	35	85	60	40	61	8	20
After	A	10	2	6	20	20	6	10	20	60	35	82	45	10	57	2	15
1st Yr.	B	5	1	4	10	5	3	8	10	60	33	81	60	30	63	7	20
3	C	1	0	2	5	3	2	3	5	46	31	80	65	50	67	15	25
After	A	30	0	2	15	40	0	3	15	30	35	85	15	0	65	10	55
3rd Yr.	B	15	0	1	10	20	0	2	10	55	31	82	20	10	69	15	60
	C	5	0	0	5	10	0	1	5	55	28	79	25	30	72	20	65

E C O N O M I C S

4/29/65

SST

M3. DESIGN COMPETITION AND PRODUCT IMPROVEMENT

The present approach to the SST Program (i.e., Option I) provides for the possibility of continuing design competition at least until January 1967. The spur of competition may lead to designs characterized by higher performance and/or lower costs than is achievable with a single development team. Through their efforts, the airframe and engine designers may substantially influence the range, payload, speed, and reliability of the aircraft. For example, improvements in the amount of fuel burned per mile traveled may not only lower operating costs, but may also be translated into:

a. more range at the same payload, thus making possible non-stop travel between more city-pairs (e.g., New York-Rome), or

b. more payload at the same range, thus increasing revenues.

Under Option I, two airframe (or engine) manufacturers compete in parallel to achieve a given set of design specifications in the same period of time. The effects of continuing this form of parallel competition on the returns to U.S. carriers on their SST Program cash flows are shown in Table M3.1, together with a hypothetical range of associated product improvement. In that table are shown the program returns (under both FAA-ORI and PRC-ORI conditions[1]) for the following situations:

a. a single development team

b. competition between two teams through prototype test, and

c. competition through certification.

In interpreting these results, we note that 5 percent improvement in total operating costs (TOC) corresponds, with ORI cost estimating relations, to 16 percent improvement in direct operating costs (DOC); 10 percent improvement in TOC corresponds to a 32 percent improvement in DOC; and 15 percent in TOC corresponds to 48 percent in DOC. Recalling that the current large jets have achieved about a 30 percent improvement in DOC since their entry into service, one sees that extended competition of the parallel form may be justified through a major improvement in aircraft performance and cost. Other reasons for fostering competition might be to provide insurance against program failure, or to improve aircraft deliveries in the case of a substantial program success, or to avoid a monopoly situation.

Table M3.2 shows the costs of varying degrees of competition under both FAA-ORI and PRC-ORI conditions. The total development cost is seen to double with parallel competition; the capital at risk at certification is seen to increase by 50 percent.

While it may appear premature at this time to concern ourselves with questions of product improvement, it should be recognized that the possibility of improvement provides the basic motivation for competition. In planning the entry of the SST into the market, we must look beyond

[1]FAA-ORI assumes FAA estimates for development and production, ORI estimates for operations. PRC-ORI assumes PRC estimates for development and production, ORI estimates for operations.

Table M3.1. Effects of Competition (and Associated Product Improvement) on Returns to U.S. Carriers

	Rate of return to U.S. carriers							
	Under FAA-ORI conditions[1] for a quantity of aircraft				Under PRC-ORI conditions[2] for a quantity of aircraft			
	50	200	400	600	50	200	400	600
1. Single development team (1 airframe and 1 engine manufacturer)	37	36	32	29	20	20	18	17
2. Competition between two teams through prototype test								
with 0% TOC improvement	27	27	24	22	10	12	11	10
" 5% " "	31	30	28	25	12	14	13	12
" 10% " "	34	34	31	28	15	17	16	14
" 15% " "	36	37	35	31	17	19	18	17
3. Competition between two teams through certification								
with 0% TOC improvement	25	25	22	20	10	12	10	10
" 5% " "	28	28	26	23	12	14	13	12
" 10% " "	31	31	29	26	14	17	15	14
" 15% " "	34	35	32	29	17	19	18	16

[1]Assumes FAA estimates for development and production; ORI estimates for operations.
[2]Assumes PRC estimates for development and production; ORI estimates for operations.

Table M3.2. Costs of Varying Degrees of Competition

	Cumulative total costs (Billion $)			
	Under FAA-ORI conditions		Under PRC-ORI conditions	
	for development	at certification (yearend 1972)	for development	at certification (yearend 1972)
1. Single development team (1 airframe and 1 engine manufacturer)	1.19	3.22	1.59	4.60
2. Competition between two teams through prototype test	2.25	4.27	3.02	6.03
3. Competition between two teams through certification	2.53	4.55	3.47	6.48

the 1972-74 time period, and consider how that product may improve and evolve. In large measure, the success of the current large jet is attributable to the introduction of the second-generation turbofan engine. This suggests that a second form of competition (here termed "leapfrog competition") might be possible, for example, if we were to choose one engine manufacturer in January 1967 to proceed toward aircraft certification in 1974, and concurrently to undertake research directed toward an advanced SST engine. Being scheduled for entry into airline service in the 1978-1980 time period, the advanced engine could incorporate design concepts superior to, but unattainable in the same time period as, the first-generation engine design effort. Such leapfrog competition might yield the following benefits:

a. assure economic success of SST Program

b. extend the useful life of the airframe design (just as in the subsonic jet)

c. sharpen engine competition without undesirable duplication of effort

d. provide insurance against failure of first engine design

e. stimulate engine technology (with military as well as civil benefit)

f. promote SST sales by creating a market bandwagon toward the SST and away from the Concorde.

During the first three to five years of operations when supply is limited, the SST is expected to run at abnormally high and profitable load factors. Thereafter, when supply and demand come into balance, load factors will decrease to more normal levels. Were an improved second-generation engine then to become available, cost reductions could be achieved over and above those resulting from normal in-service improvements, and returns on investment could then be further increased. Knowledge that a second-generation engine is planned for introduction into service in 1978-1980 would greatly reduce the SST Program risks in terms of decision-making today--for the Government, the airlines, and the manufacturers.

NASA and DOD are currently sponsoring advanced engine research, but it is at a low level and there is no direct linkage to the SST Program.